

**CLAIMS:**

1. A formatted optical medium having a formatting pattern including registration marks for enabling data to be written to or read from a desired location in a monolithic bulk of the optical medium, said registration marks being arranged in at least one base layer;

characterized in that:

the at least one base layer is formed within a bulk of the optical medium displaced from an outer surface thereof.

2. The formatted optical medium according to claim 1, wherein, in use, the at least one base layer serves as a guide for writing data at respective data layers in the medium associated with the at least one base layer without requiring pre-formatting of said data layers.

3. The formatted optical medium according to claim 1 or 2, wherein respective registration marks are contained in multiple base layers all formed within a bulk of the optical medium displaced from an outer surface thereof, such that adjacent base layers have a known mutual separation and each base layer, in use, serves as a guide for writing data at respective multiple data layers in the medium associated with the respective base layers.

4. The formatted optical medium according to any one of claims 1 to 3, wherein the registration marks are angularly tilted.

5. The formatted optical medium according to any one of claims 1 to 4, wherein the registration marks are of controlled size and length.

6. A method for writing data to  $M$  multiple layers all associated with a common base layer in the formatted optical medium according to any one of claims 1 to 5 using a write spot that is spatially offset from a read spot by a controlled offset, said method comprising:

focusing the reading head in controlled registration with the common base layer and writing data to a first data layer ( $L = 1$ ) of said data layers so as to be displaced from the common base layer by said fixed offset; and

for each subsequent data layer  $L$  ( $2 \leq L \leq M$ ), focusing the reading head in controlled registration with a previous data layer ( $L - 1$ ) and writing data to said data

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layer ( $L$ ) so as to be displaced from the previous data layer ( $L - 1$ ) by said controlled offset.

7. A formatter for inscription of marks on to a monolithic 3D translucent optical medium to enable recording and retrieval of information in the medium, , the  
5 formatter comprising:

at least one optical unit calibrated to focus at least one diffraction limited spot within the medium at a respective depth therein displaced from an outer surface thereof,

10 at least one light source optimized for the inscription of marks including registration marks that enable data to be written to or read from a desired location in the optical medium, said registration marks being arranged in at least one base layer formed within a bulk of the optical medium displaced from an outer surface thereof displaced from an outer surface thereof,

15 at least one actuator for moving said at least one diffraction limited spot relative to the medium, and

a controller for controlling fluctuations in ambient conditions in order to attenuate formatting variations caused thereby.

8. The formatter according to claim 7, wherein the medium is disc shaped and the motion of the spot relative to the medium is via rotation of the disc and motion of  
20 the optical unit.

9. The formatter according to claim 7 to 8, wherein the optical unit includes a beam splitting mechanism for splitting the beam whereby a plurality of oblong marks are inscribed simultaneously.

10. The formatter according to claim 7, wherein the optical unit is an assembly  
25 including a plurality of accurately calibrated optical units each being focused at a different depths and relative movement between the assembly and the media inscribes a multitude of tracks simultaneously.

11. The formatter according to any one of claims 7 to 10, further including a clamping unit for holding a stack of disks in precise mutual spatial disposition, to be  
30 accessed by a multitude of optical units and actuated by a multitude of actuators.

12. The formatter according to any one of claims 7 to 11, wherein the registration marks are angularly tilted.

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13. The formatter according to any one of claims 7 to 12, wherein the registration marks are of controlled size and length.

14. A formatted 3D translucent monolithic optical medium having a formatting pattern that is generated by a formatter according to any one of claims 7 to 13 so as to  
5 allow information to be recorded and read back without requiring that the medium have a physically layered structure.

15. The formatted optical medium according to claim 14, wherein discrete servo offsets in 3D or a continuous range of servo offsets in 3D, are used to obtain a 3D tracking error signal.

10 16. The formatted optical medium according to claims 14 or 15, wherein the formatting pattern comprises zoned spirals or circles in which sectors and headers are encoded.

17. The formatted optical medium according to any one of claims 14 to 16, having an arrangement of alternating oblong servo marks that define tracks in adjacent virtual  
15 layers such that the servo marks arrangement is equivalent to a triplet or a quadruple of servo indicators and such that the count of indicators is equal to the number of tracks intervals.

18. The formatted optical medium according to any one of claims 14 to 17, wherein the registration marks are angularly tilted.

20 19. The formatted optical medium according to any one of claims 14 to 18, wherein the registration marks are of controlled size and length.

20. A tracking and formatting system for tracking data stored in a 3D formatted monolithic optical medium, said tracking and formatting system comprising:

an optical unit adapted to focus at least two laser beams of possibly mutually  
25 different wavelengths at respective points in the optical medium having a controlled mutual displacement, so as to form a read spot that is used to obtain a read signal from the optical medium and a write spot that is used for recording registration marks for enabling data to be written to or read from a desired location in the optical medium, said registration marks being arranged in at least one base layer formed within a bulk  
30 of the optical medium displaced from an outer surface thereof,

a non-position sensitive detection unit coupled to the tracking unit and being responsive to the tracking signal generated thereby for reading data marks stored in

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data layers of said optical medium independent of a spatial structure of the detection unit, and

a tracking unit for generating a tracking signal that conforms to the formatting pattern in said 3D formatted optical medium to enable calculation of a tracking error signal that is used as feedback for servo-mechanisms that control the precise location of a read spot according to said formatting pattern, said tracking unit being responsive to the read spot for tracking an information track in a layer that is at least partially recorded and/or servo marked.

21. The tracking and formatting system according to claim 20, further comprising:

a plurality of at least partially recorded base layers having a known mutual separation; and

an optical unit enabling data to be read with one wavelength and data recording with another wavelength.

22. The tracking and formatting system according to claim 21, wherein the base layers include test areas to validate that there is no over-writing of the base layers.

23. The tracking and formatting system according to claim 20, wherein the registration marks are arranged in a plurality of discrete offsets or a continuous range of radial, axial or angular offsets.

24. The tracking and formatting system according to claim 20, wherein said registration marks and the data marks are of different sizes and lengths.

25. The tracking and formatting system according to any one of claims 20 to 24, wherein:

the formatting pattern comprises a multitude of intervals along each data track, each of said intervals having a respective type that indicates a property of the data associated with the interval.

26. The tracking and formatting system according to any one of claims 20 to 24, wherein any variations in the fixed offset between the read and write spots is corrected by tracking error signals of the form:

$$\frac{(A \cdot S1 - S2) - B}{D \cdot (E \cdot S1 + S2)}$$

where:

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S1 and S2 are the respective signal amplitudes from the two offset mark sequences;

A and B are symmetry breaking factors; and

$D \cdot (E \cdot S1 + S2)$  is a general normalization factor.

5 27. The tracking and formatting system according to any one of claims 20 to 26, wherein two pairs of servo offset marks are used in each axis to obtain servo indication.

28. The tracking and formatting system according to claim 27, wherein the servo offsets include servo offsets of two different magnitudes and any variations in the  
10 fixed offset between the read and write spots is corrected by a track error signal of the form:

$$\frac{A \cdot (B \cdot S1 - S2) + C \cdot (D \cdot S3 - S4)}{I \cdot (E \cdot (S1 + F \cdot S2) + G(S1 + H \cdot S2))}$$

where:

15 S1, S2, S3 and S4 are the respective signal amplitudes of the four offset mark sequences;

A, B, C and D are symmetry breaking factors; and

$I \cdot (E \cdot (S1 + F \cdot S2) + G(S1 + H \cdot S2))$  is a general normalization factor.

20 29. The tracking and formatting system according to claim 25, wherein said intervals include two types relating respectively to user data and to servo and system information.

30. The tracking and formatting system according to claim 25, wherein said intervals include two types of intervals having respective zoned constant linear lengths a first being dedicated mostly to user data and a second being dedicated mostly to servo and system information.

25 31. The tracking and formatting system according to claim 25, wherein said intervals include two types of intervals having respective zoned constant angular lengths a first being dedicated mostly to user data and a second being dedicated mostly to servo and system information.

30 32. The tracking and formatting system according to any one of claims 29 to 31, wherein the intervals have a pseudo-random variation of length.

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33. The tracking and formatting system according to any one of claims 20 to 32, wherein the formatting pattern comprises zoned spirals or circles in which sectors and headers are encoded.

5 34. The tracking and formatting system according to any one of claims 20 to 33, having an arrangement of alternating registration marks that define data tracks in adjacent virtual layers such that the registration marks arrangement is equivalent to a triplet or a quadruple of servo indicators and such that the count of indicators is equal to the number of data tracks intervals.

10 35. The tracking and formatting system according to any one of claims 20 to 34, wherein the formatting pattern encodes auxiliary information in addition to nominal track center.

36. The tracking and formatting system according to any one of claims 20 to 35, being adapted for recording content in the course of the formatting process.

15 37. The tracking and formatting system according to any one of claims 20 to 36, wherein the registration marks are angularly tilted.

38. The tracking and formatting system according to any one of claims 20 to 37, wherein the registration marks are of controlled size and length.